# Planetary Field Geology

## One Way or Another

K.V. Hodges
School of Earth and Space Exploration
Arizona State University

# Roadmap

- The terrestrial way
- The Apollo way
- The MER way
- The flexible path
- A plea for strategic metaplanning
- The impact of latency on planetary field geology

# Terrestrial Field Geology

Concepts
Protocols

# On Earth

- The goal is to constrain the plausible geologic histories of a study area
- Involves the development and testing of multiple working hypotheses
- The principal data product is a geologic map
- Other data and samples are collected to validate interpretations and to better constrain plausible histories

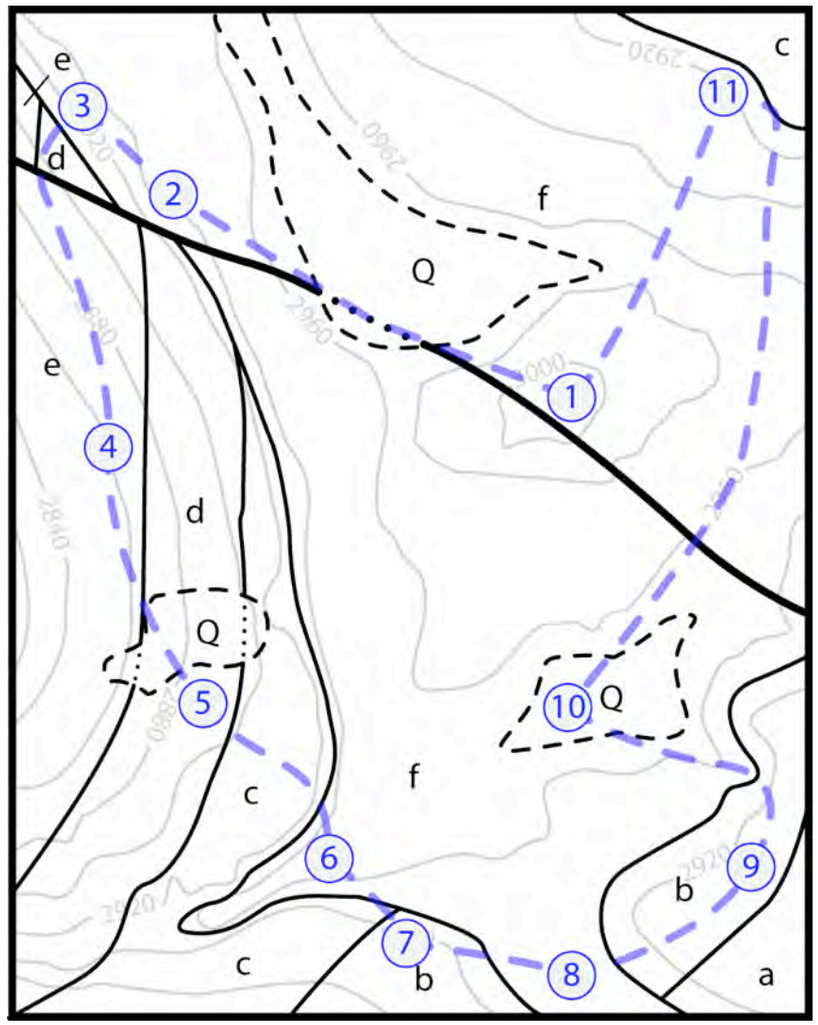
# On Earth

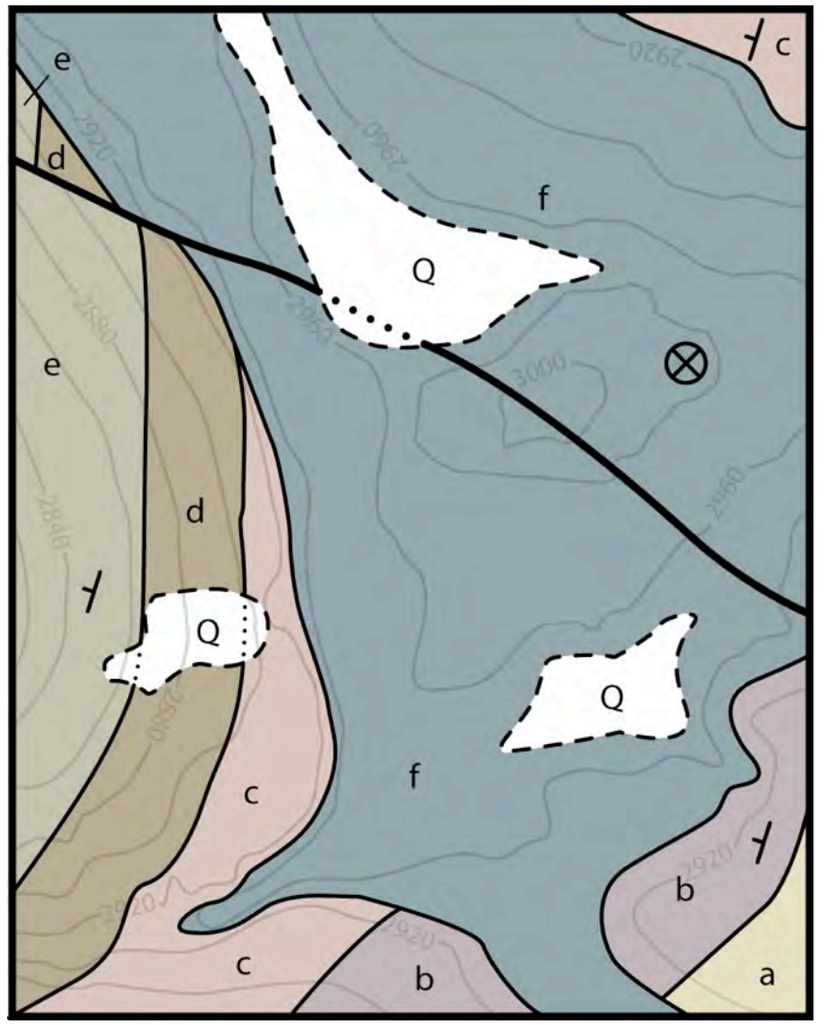
- Preliminary interpretations are based on remote sensing

- Traverses are planned to test these interpretations, but...

- Almost no traverses are carried out as initially planned, and instead evolve as a consequence of observations

- Observations at multiple scales and from multiple perspectives are essential




# Evolution of traverse plans and geologic interpretations

# Lunar Field Geology

## The Apollo Legacy

Concepts
Protocols

# During Apollo

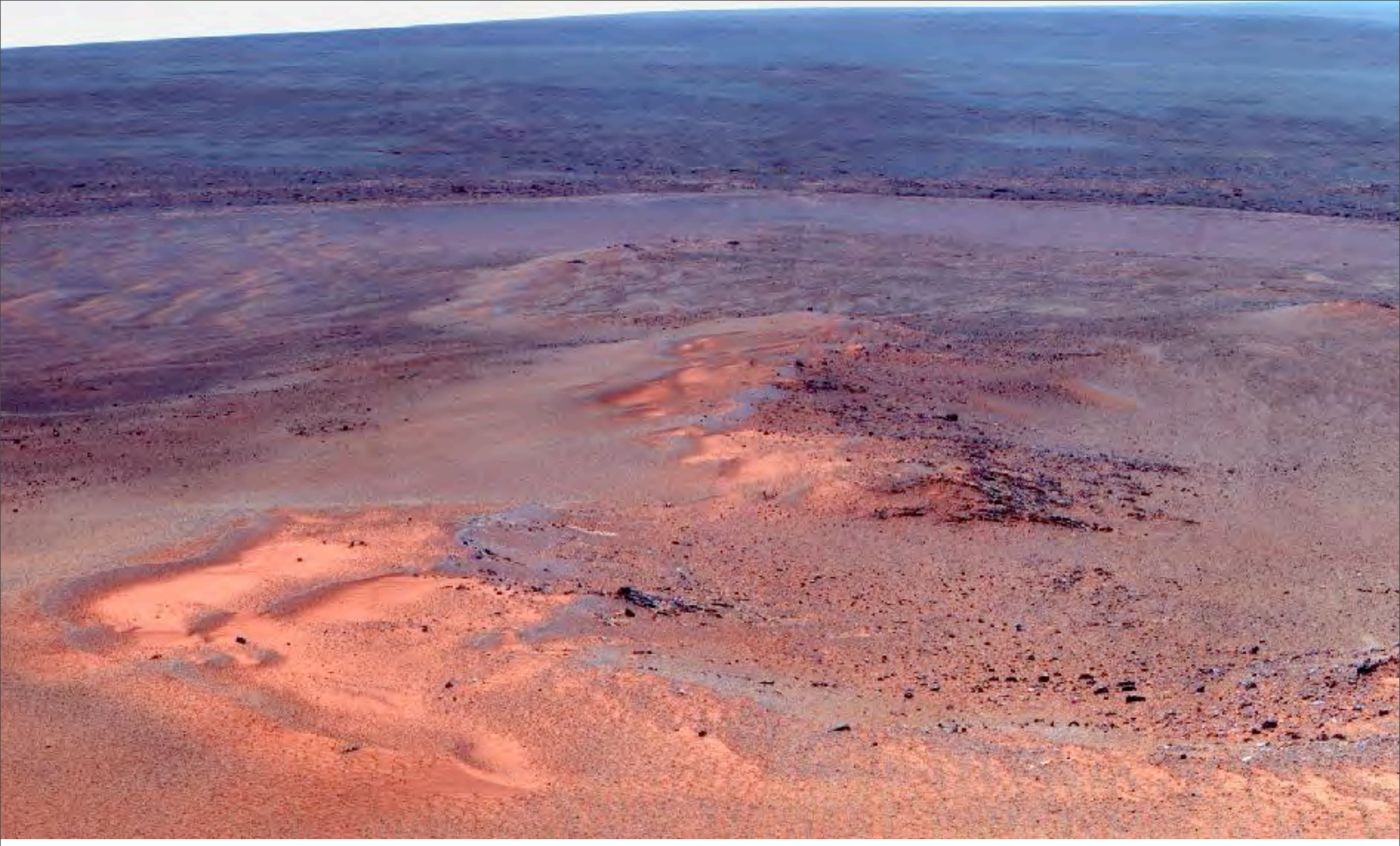
- The goal was to improve understanding of the evolution of the Moon largely through data and sample collection for analysis by scientists back on Earth

- Traverses and timelines were carefully choreographed

- Most flexecution took place at stations

- Methods were derivative of terrestrial field geology with low reliance on high technology

How the times aren’t changing...



# Martian Field Geology

## The Mars Exploration Rovers

Concepts
Protocols

# During the MER Expeditions

- The goal has been to improve understanding of the evolution of Mars through remote data collection by scientists back on Earth

- Flexecution is the norm

- The technology is very high

- The tempo of exploration is constrained by technology – and distance

# The Flexible Path

## Collaborative Exploration

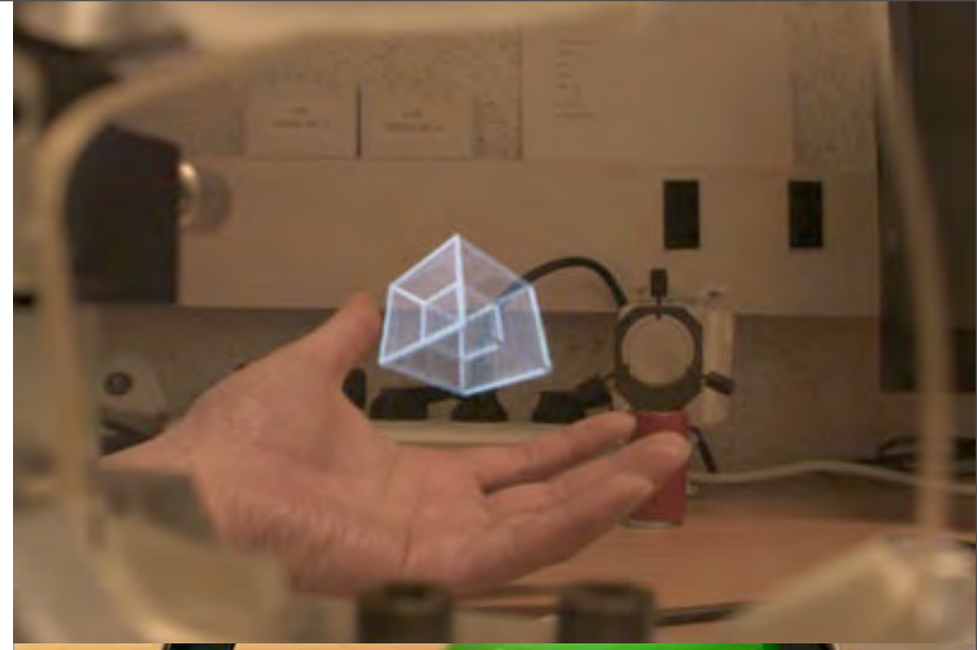
Concepts
Protocols

# A New Way

- The goal will be to improve geologic understanding through coordinated and integrated human and robotic exploration
- Near-autonomous field research by humans, including on-site sample analysis
- Increased emphasis on sample selectivity prior to return
- Technologies must be developed to extend and enhance the pace of research activities – not retard them

# Enhanced Capacity

- Wearable computing
- Augmented reality
- Real-time tutoring
- Better science



# Are Humans Necessary?

- Field geology – or any science that relies on creative thought rather than rule-based execution – seems impossible with autonomous robots

- The MER rovers have demonstrated the value of teleoperated robots for field geology – by humans

- If we expect to do excellent field geology on other worlds, reliance on human cognition is essential

# Better Telescience Demands Lower Cognitive Overhead

- Extensive testing on Earth demonstrates that technology is a boon to field data collection but an impediment to research efficiency

- Robot operations are far from intuitive at present

- If the goal is to do the best science in the most efficient way, we need scientists and engineers to work together to build robots that are at least as capable as the body and mind of a human geologist – if not more so!

# What About Low-Latency Telescience?

- What if we we could establish a base station for robotic field geology that is sufficiently close to a planetary surface that the two-way communication time is imperceptibly short...

- Could we not then focus on the development of robotic functions to enable scientific tasks, but use human cognition to do research more efficiently and with more robust results?

- Could we develop a geologist avatar? Is that worth the trouble? And how should we proceed if it is?